

AD-A279 661



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FY93 End of Fiscal Year Letter
(01 Oct 1992 - 30 Sep 1993)

ONR Contract Information

Contract Title: Materials Research for GHz Multi-Chip Modules

Performing Organization: Georgia Institute of Technology

Principal Investigator: Paul A. Kohl

Contract Number: N00014-91-J-4008

R&T Project Number:

ONR Scientific Officer: Larry T. Kabacoff

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Letter Report

A. Goals:

The goal of this program is to investigate new dielectrics, metals and processes for the fabrication and characterization of multi-chip modules (MCM) which hold the promise of excellent performance, cost and yield for high frequency MCMs.

B. Significant Results:

First, the processes for using noble metals (gold and silver) as the interconnection metallization in the module have been investigated. Noble metal processes can have fewer processing steps (particularly for gold) than the equivalent copper process and are potentially lower cost, particularly when high reliability is important. The silver process has been developed so that the silver maintains its bulk conductivity (highest of conventional metals) and has low residual stress during high temperature processing. The commercialization of the silver process is being considered.

Second, a unique adhesion material has been investigated and is currently being investigated for commercial use. We are in the process of evaluating the process and with n-Chip and transferring the technology to them.

Third, numerous low dielectric constant insulators have been evaluated through the fabrication of in-situ test structures using noble metals. Through-plane properties are of particular importance. Rapid processing techniques for several polymers have been developed which significantly shorten the processing time. The investigation of new, low cost, low dielectric constant polymers are begun. In-situ measurements of

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dielectric constant and loss at frequencies up to 10 GHz are being measured to verify the dielectric properties.

C. Future Plans:

We plan to work on the completion of several of the tasks. We have also added two tasks to the original statement of work. The test wafers used by ourselves and Mayo, for evaluation of materials and processes will be fabricated and tested. The tests include high frequency testing, and physical measurements (CTE, moisture, etc).

The development of specific test structures for evaluation of in-plane and through-plane CTE, modulus and dielectric constant will be completed.

We have added tasks based on our interactions with n-Chip. The use of the low cost adhesion layers will be extended to include tantalum. There is a great deal of interest in evaluation silver for interconnections. Silver is the highest conductivity material at room temperature, however, it has had reliability problems due to ionic migration. There are several reasons to revisit the issues based on the reported failure mode.

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D. List of Publications/Reports/Presentations

1. Papers Published in Refereed Journals:

Cloud, T., Houston, M., Kohl, P.A., and Bidstrup, S.A., "High Performance Noble Metal MCMs" IEEE CHMT, 16, 724-730 (1993).

Hodge, T.C., Landmann, B., Kohl, P.A., and Bidstrup, S.A., "Rapid Thermal Curing of Polymer Interlayer Dielectrics" Journal of Microcircuits & Electronic Packaging, submitted.

S. Han, M. Ceiler, S. Bidstrup, P. Kohl, and G. May, "Modeling the Properties of PECVD Silicon Dioxide Films Using Optimized Back-Propagation Neural Networks," to appear in IEEE Transactions on Components, Hybrids, and Manufacturing Technology, submitted.

Lin, L., and Bidstrup, S.A., "Processing Effects on Optical Anisotropy in Spin Coated Polyimide Films", Journal of Applied Polymer Science, 49, 1277 (1993).

Lin, L., and Bidstrup, S.A., "Effect of Molecular Orientation on the Dielectric Properties of Spin-Coated Polyimide Films", Journal of Applied Polymer Science, October (1993).

Vogt, K., Kohl, P.A., Bell, R., Bottomley, L.A., and Carter, B., "Characterization of Thin Titanium Oxide Adhesion Layers on Gold: Resistivity, Morphology, and Composition.", Surface Science, accepted for publication.

Vogt, K.W., Houston, M., Ceiler, M.F., Roberts, C.E., and Kohl, P.A., "Stablization of Low Temperature PECVD SiO₂ for Electronic Packaging", Journal of Electronic Materials, Submitted.

2. Non-Refereed Publications:

Laursen, K., Hertling, D., Berry, N., Bidstrup, S.A., Kohl, P., and Arroz, A., "Measurement of the Electrical Properties of High Performance Dielectric Materials for Multichip Modules", to be published in 1994.

3a. Invited Presentations

Bidstrup, S.A., "Anisotropy in Thermal, Electrical, and Mechanical Properties" Materials Research Society, San Francisco, CA.

Kohl, P.A., Ceiler, M.F., Bidstrup, S.A., and May, G., "The Effect of Deposition Conditions on the Properties of PECVD Silicon Dioxide Films", The Electrochemical Society, vol. 93-12, 265-6, Honolulu, HI, May 1993.

Kohl, P.A., "Metallurgy and Processing for Advanced Mixed Mode Electronic Packaging" Invited presentation to the Defense Sciences research Council, July 8, 1993.

Frye, D.C., Harris, R.H., Heistrand, R.H., Moyer, E.S., Rutter, E.W., Garrou, P., Berry, M.J., Rogers, B., Turtlik, I., Bidstrup, S.A., Hodge, T., Kohl, P.A., Taylor, G., Berry, K., David, F., and Lanka, M., "Via Generation in Cytclotene", VLSI Packaging, Kyoto, Japan December 2, 1992.

3b. Contributed

Houston, M., Cloud, T., Redd, R., Taylor, G., Kohl, P.A., and Bidstrup, S.A., "Evaluation of the Processing and Performance of Noble Metal MCMs", ISHM, Denver CA, April, 1993.

Sinno, B. Bidstrup, S.A., and Kohl, P.A., "Characterization of Polymer Dielectrics for Use in Low Temperature Electronic Applications", Materials Research Society, Palo Alto, CA, Spring 1993.

Hodge, T., Bidstrup, S.A., and Kohl, P.A., "The Effect of Moisture and Temperature on the Dielectric Properties of Polyimides", The Electrochemical Society, vol. 93-12, 451-2, St. Louis, MO, October 1992.

Han, S.S., Ceiler, M., Bidstrup, S.A., Kohl, P.A., May, G., "Emperical Modleing of Plasma Enhanced CVD of Silicon Dioxide Using Neural Networks", SPIE Conf. on Microelectronics, Monterey, CA , Sept. 1993.

Sinno, B., Bidsrtup, S.A., and Kohl, P.A., "Effect of Cure Schedule on Stress in Polyquinoline Films", Society of Plastic Engineers, 1993.

Lin, L., and Bidstrup, S.A., "Effect of Processing Variations on the Molecular Orientation of Spin-Coated PMDA-ODA Polyimide Films", ACS Division of Polymeric Materials, Fall 1992.

Hertling, D.R., Laursen, K., Bidstrup, S.A., Kohl, P.A., Arrozo, G.S., "Measurement of the Electrical Properties of High Performance , Low Cost Dielectric Materials for Multichip Modules." IEPC, San Diego, CA, September 1993.

Lin, S.A., and Bidstrup, S.A., "The DEvelopment of In-Plane Orientation in Spin-Coated Polyimide Films", AICHE Annual Meeting, Miami, FL, November 1992.

F. Participants and Their Status.

Ph.D

Thomas Hodge

Advising Began: Winter 1990

Comprehensive Examination Passed: Summer 1991

Graduation Date: Spring 1995

Thesis Title: Microstructures for Measuring Mechanical and Thermal Properties of Thin Polymer Structures.

Anne Sullivan

Advising Began: Winter 1990

Comprehensive Examination Passed: Summer 1991

Graduation Date: Spring 1995

Kirkland Vogt

Advising Began: Winter 1989

Comprehensive Examination Passed: Summer 1990

Graduation Date: Spring 1994

Thesis Title: Low Temperature Chemical Vapor Deposition of Metal Nitride Films for III-V Semiconductor Passivation.

Kirk Laursen

Advising Began: Fall 1991

Comprehensive Examination Passed: Summer 1992

Graduation Date: Winter 1994 (M.S.)

Thesis Title: High Frequency Electrical Measurements

Nicole Grove (co-advisor with Sue Ann Bidstrup)

Advising Began: Fall 1993

Comprehensive Examination Passed:

Graduation Date: Spring 1998

Thesis Title: Polyolefins as use as Interlevel Dielectrics

M.S.

Bilal Sinno

Advising Began: Fall 1991

Comprehensive Examination Passed: Summer 1992

Graduation Date: Winter 1994 (M.S.)

Thesis Title: Low Temperature Interlevel Dielectrics

Martin Ceiler

Advising Began: Fall 1991

Comprehensive Examination Passed: M.S. only.

Graduation Date: Fall 1993

Thesis Title: Inorganic Dielectrics for GHz Multi-Chip Modules

Geneva Tatem

Advising Began: Fall 1992

Comprehensive Examination Passed:

Graduation Date: Unknown

Thesis Title: Electromigration and Moisture Studies in GHz Multi-Chip Modules

Undergraduates

Gareth Sampson, Winter 1991 to Spring 1992, "Reactive Ion Etching"

George Williams, Spring 1991, "Statistical Process Control"

Todd Cloud, Spring 1991 to Present, "Photosensitive Polyimides"

Ralph Redd, Fall 1991 to Present, "Semiconductor Metallization"

Ajay Patel, Winter 1992, "Surface Topography of Etched GaAs"

Cosandra Farmer, Summer 1992-Present, "Photolithography"

Barry Coe, Summer 1992-Winter 1992, "Electroplating"

Christine Roberts, Fall 1992 to present, "Chemical Etching"

Carnley Norman, Winter 1993 to present, "Reactive Ion Etching"

George Obath, Winter 1993- present, "Electroplating"

Clifford Henderson, Spring 1993-present, "Rapid Processing of Materials"

Tim Huskey, Fall 1992-present, "Electroless Plating of Gold"

G. Other Sponsored Research

1. High Temperature Superconductor Multi-Chip Modules.

E-Systems Inc. (Prime contractor to DARPA)

Amount Funded, \$375,000 (10/16/91 to 10/15/94)

Time Spent on Project: 1/6 time.

**H. SUMMARY OF FY93
PUBLICATIONS/PATENTS/PRESENTATIONS/HONORS/PARTICIPANTS
(Number Only)**

	<u>ONR</u>	<u>non ONR</u>
a. Number of Papers Submitted to Referred Journal but not yet published:	<u>2</u>	<u>1</u>
b. Number of Papers Published in Referred Journals:	<u>5</u>	<u>6</u>
c. Number of Books or Chapters Submitted but not yet Published:	<u>0</u>	<u>0</u>
d. Number of Books or Chapters Published:	<u>0</u>	<u>0</u>
e. Number of Printed Technical Reports & Non-Referred Papers:	<u>8</u>	<u>7</u>
f. Number of Patents Filed:	<u>0</u>	<u>1</u>
g. Number of Patents Granted:	<u>0</u>	<u>0</u>
h. Number of Invited Presentations at Workshops or Prof. Society Meetings:	<u>4</u>	<u>4</u>
i. Number of Contributed Presentations at Workshops or Prof. Society Meetings:	<u>8</u>	<u>10</u>
j. Honors/Awards/Prizes for Contract/Grant Employees: (selected list attached)	<u>0</u>	<u>0</u>
k. Number of Graduate Students and Post-Docs Supported at least 25% this year on contract grant:	<u>8</u>	<u>8</u>
Grad Students: TOTAL	<u>8</u>	<u>8</u>
Female	<u>3</u>	<u>2</u>
Minority	<u>1</u>	<u>0</u>
Post Doc: TOTAL	<u>1</u>	<u>0</u>
Female	<u>0</u>	<u>0</u>
Minority	<u>0</u>	<u>0</u>
l. Number of Female or Minority PIs or CO-PIs		
New Female	<u>1</u>	<u>1</u>
Continuing Female	<u>1</u>	<u>1</u>
New Minority	<u>1</u>	<u>1</u>
Continuing Minority	<u>1</u>	<u>1</u>

Enclosure (4)